MUCOOL
Liquid Hydrogen Absorber R&D
Absorber window

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Presentation headlines

- **Absorber window thickness measurements**
  - **Set-up and procedure**
  - **Results**
- **Numerical analysis of the windows**
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  - **0.36 mm thick window**
- **Set-up and instrumentation of the test pressure**
  - **Goal**
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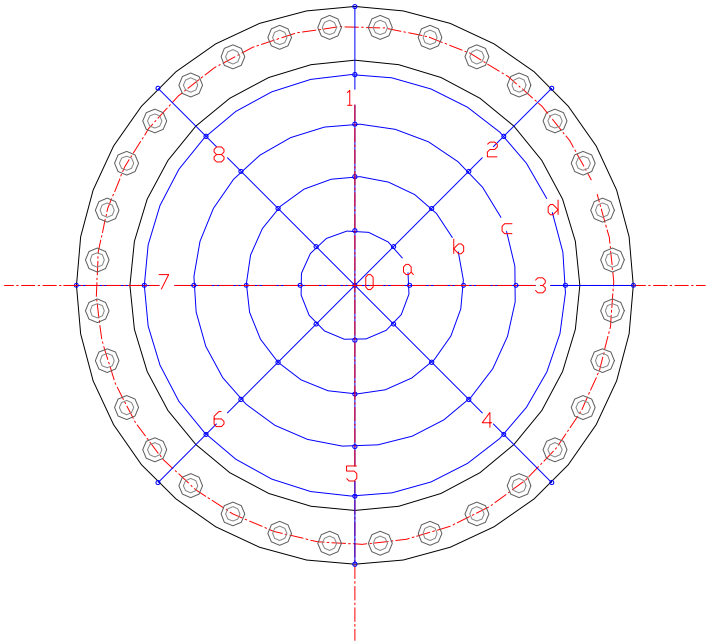
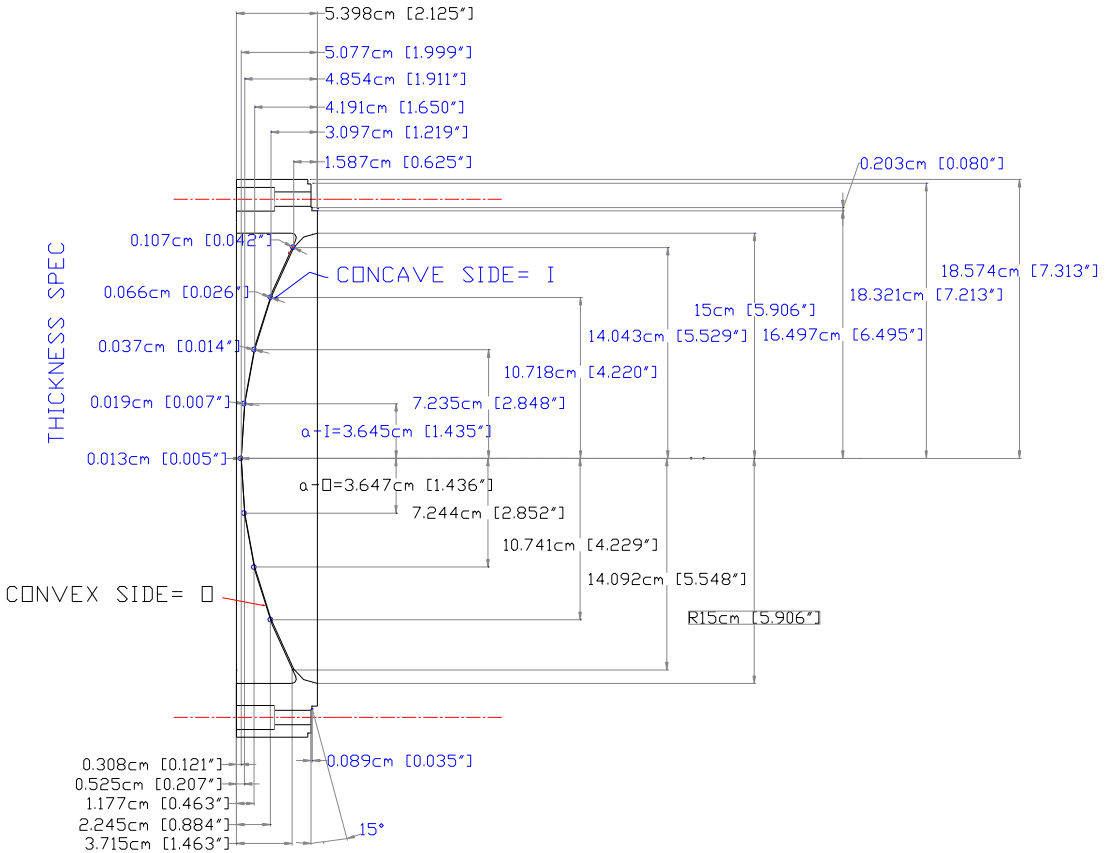
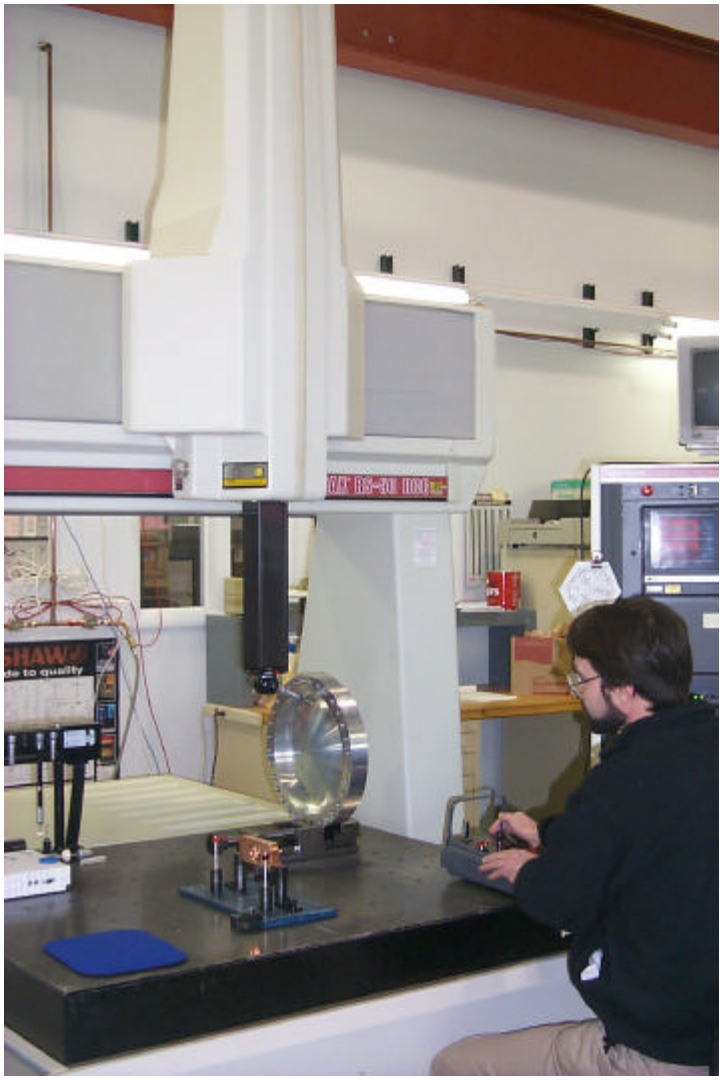
  - **Instrumentation**

Absorber window thickness measurements



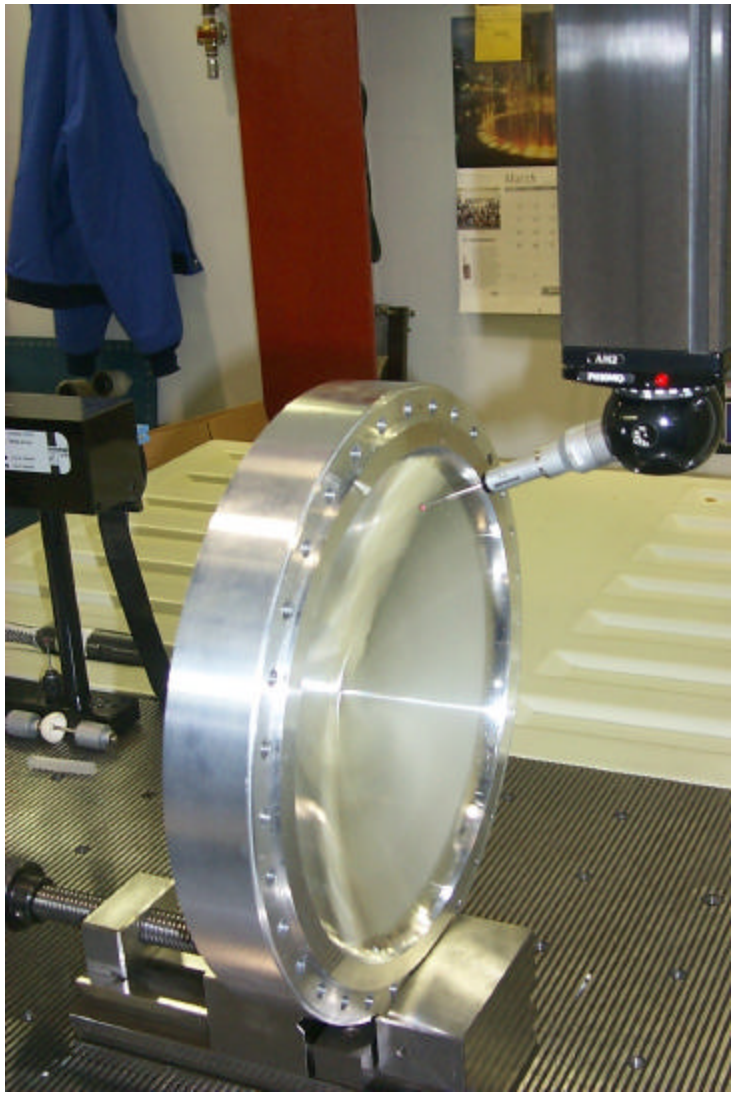


Absorber window thickness measurements

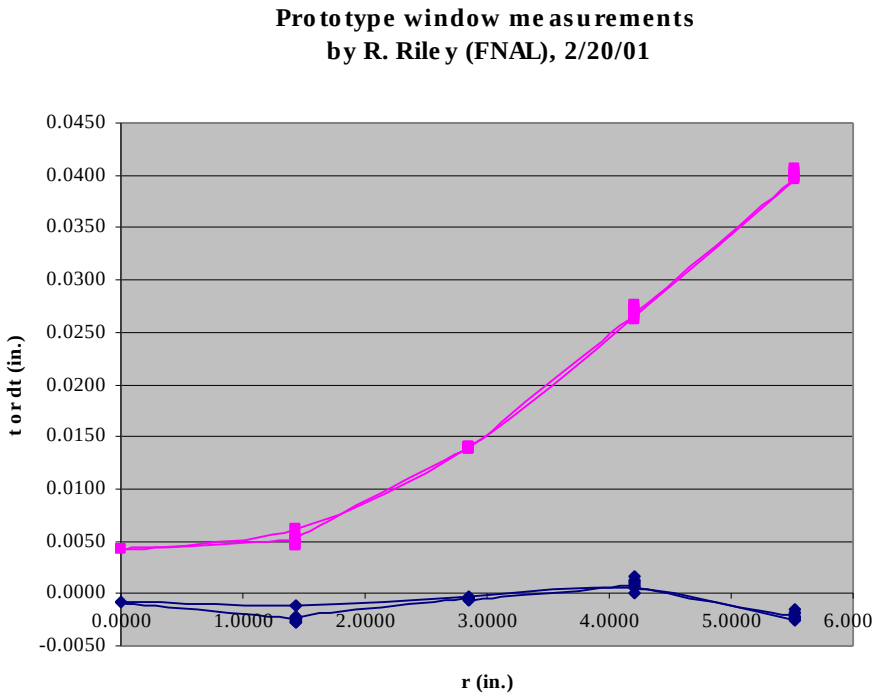


Measurements performed at the material control/ FNAL

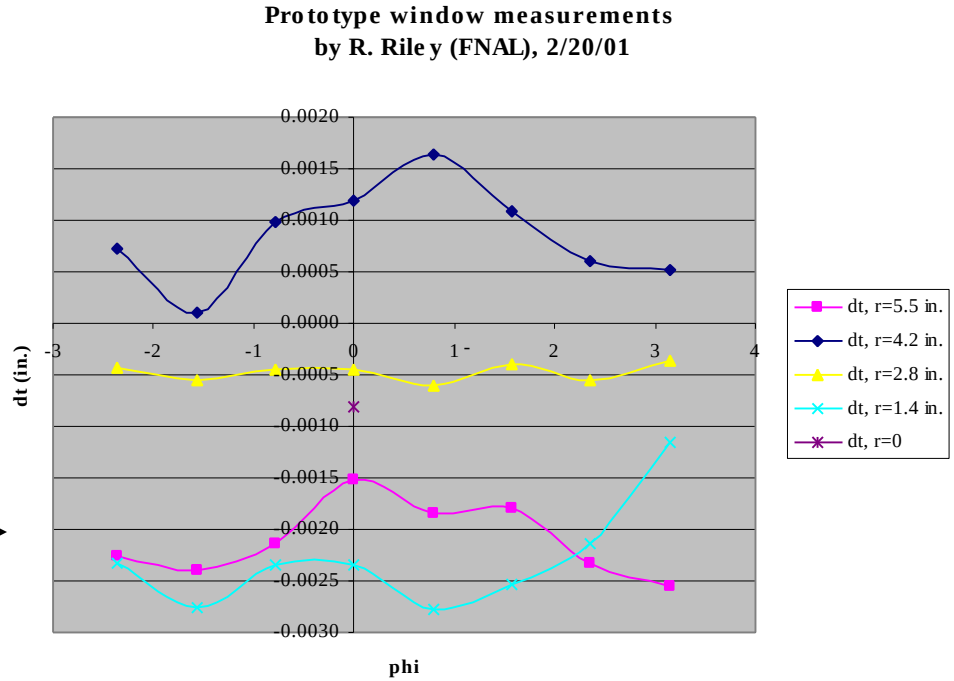
Absorber window thickness measurements



Absorber window thickness measurements

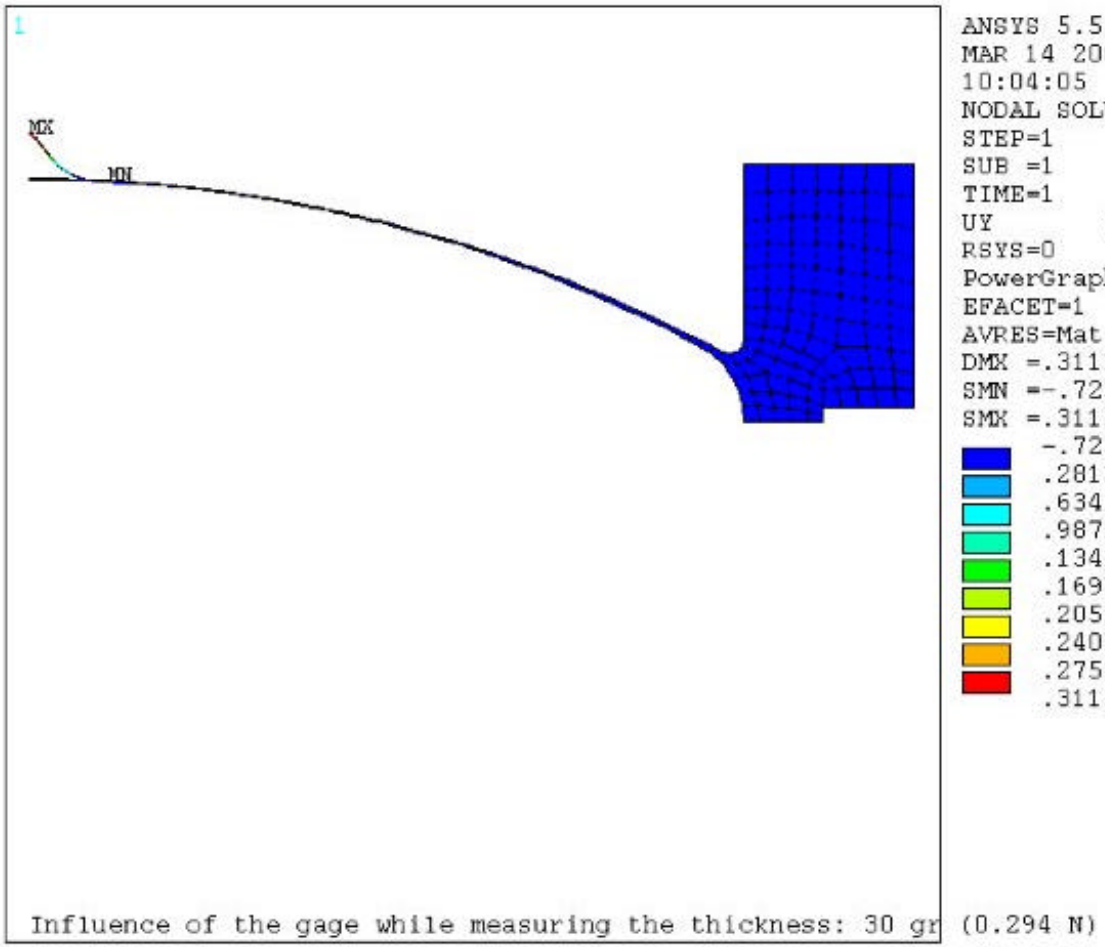


Measurement with a probe oriented along the axis



Measurement with a probe oriented along the axis

Absorber window thickness measurements

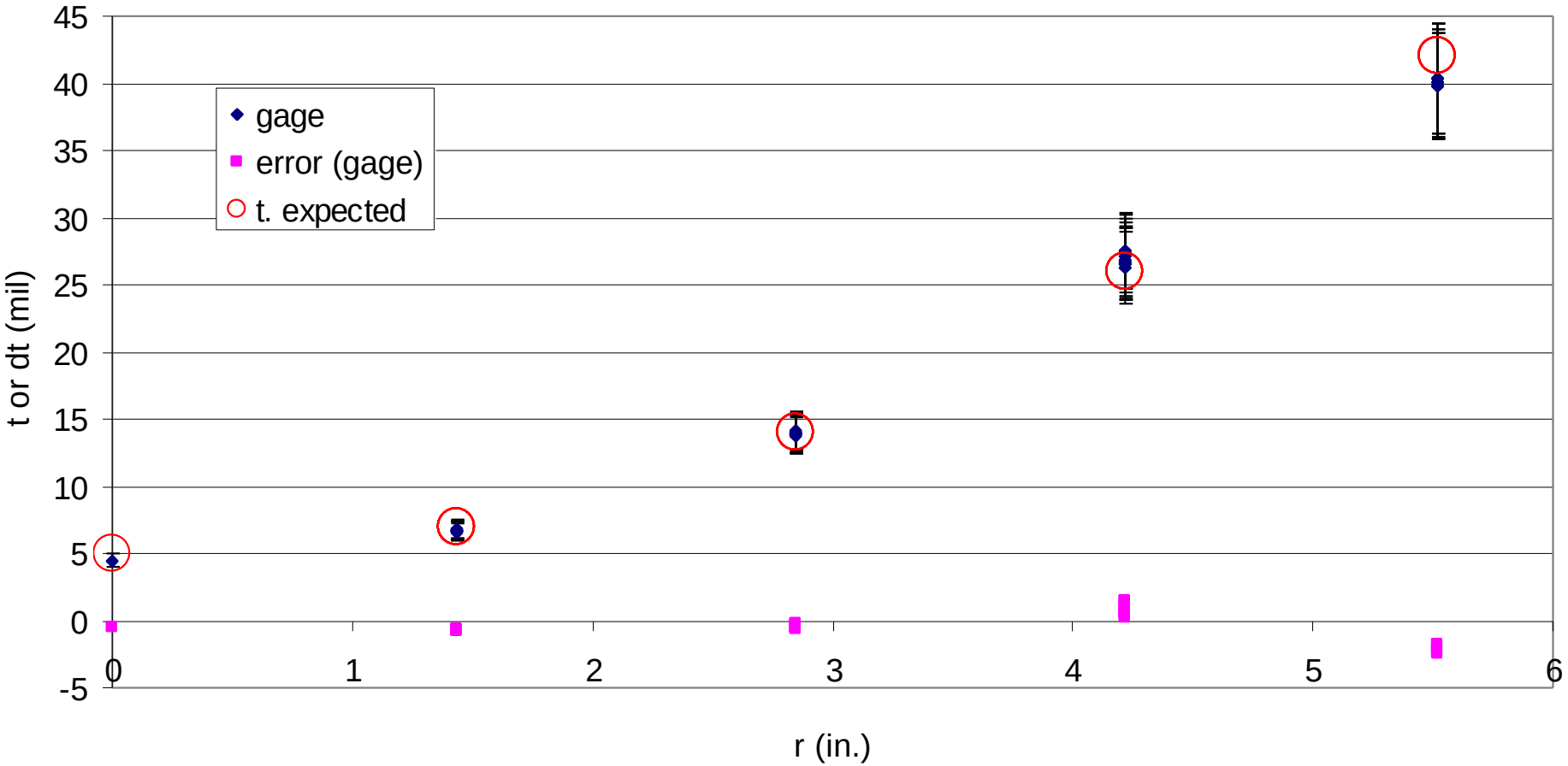


C/C: A deflection of .3μm should be noticed.

Measurement of the thickness with a probe oriented according to a 30degre angle.

Absorber window thickness measurements

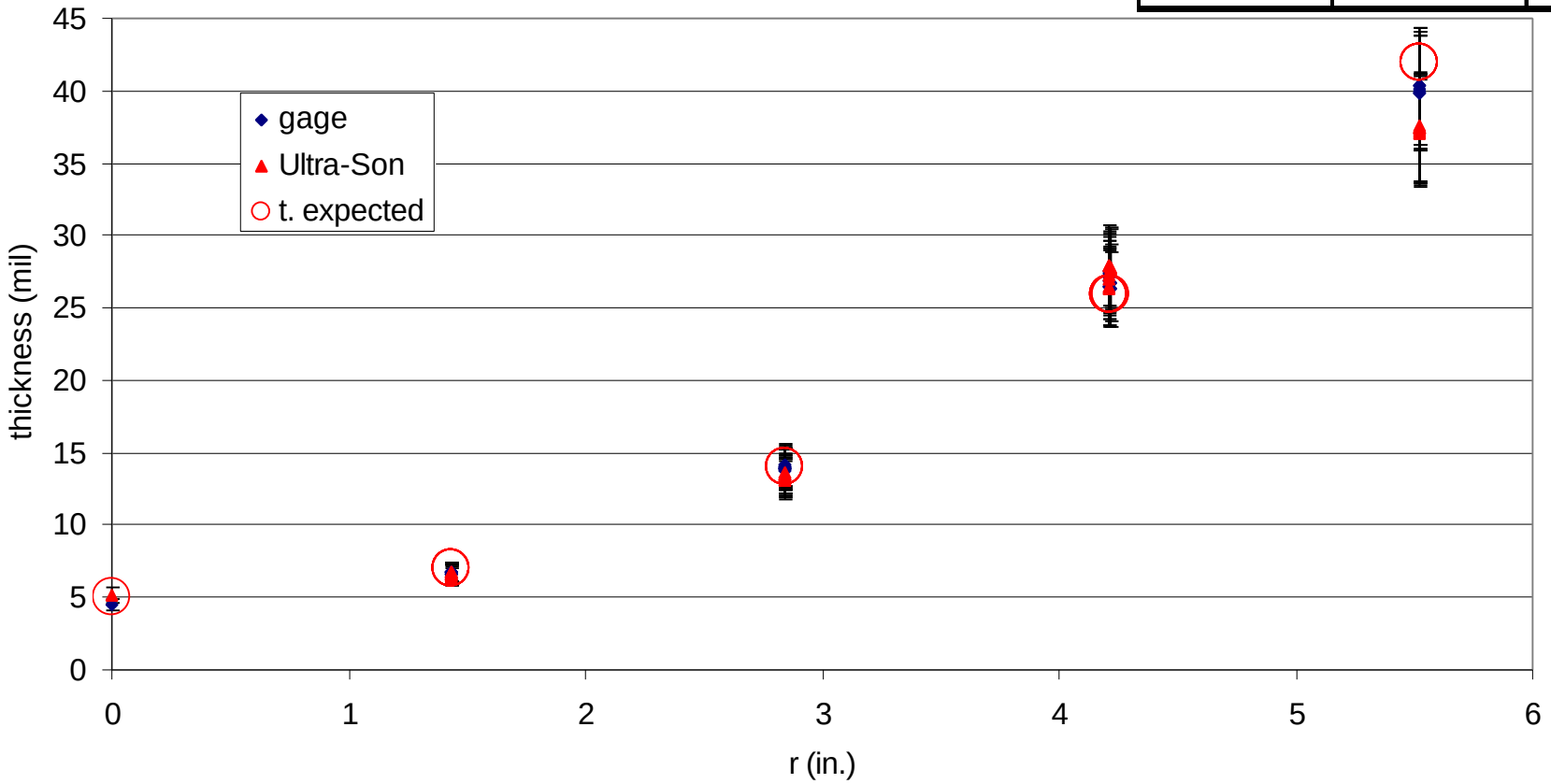
Prototype window measurements
by R. Riley (FNAL), 2/20/01



Absorber window thickness measurements

Radius	Gage	Ultra-Son
5.5	0.2308	0.162813
4.2	0.465034	0.501478
2.8	0.122519	0.147094
1.4	0.04082	0.075037

Prototype window measurements
by R. Riley (FNAL), 2/20/01



Numerical analysis of the windows

Goal:

Modelization of the behavior of the absorber window

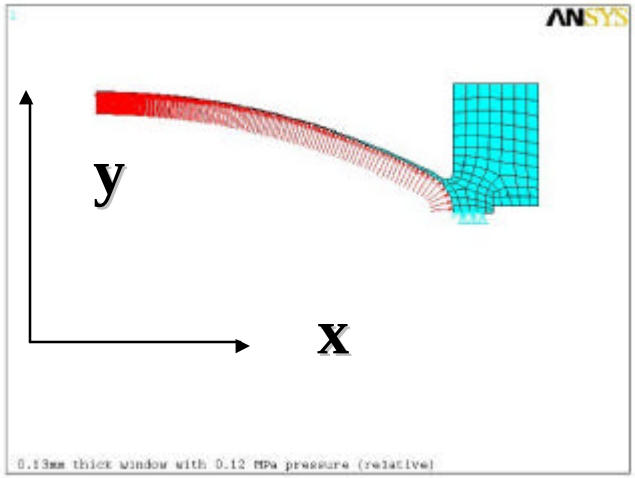
for the process of acceptance of the manufacture of the serial windows.

Procedure:

1- Calculations of the deflection, strain and stress for the 0.13mm thick window.

The strains are showed in order to be checked by the measurements performed with the pressure test - up to rupture. => validation of the FEA.

2- Calculations of the 0.36mm thick window.



Definitions:

Axisymetric model

E= 68.10^3 Mpa

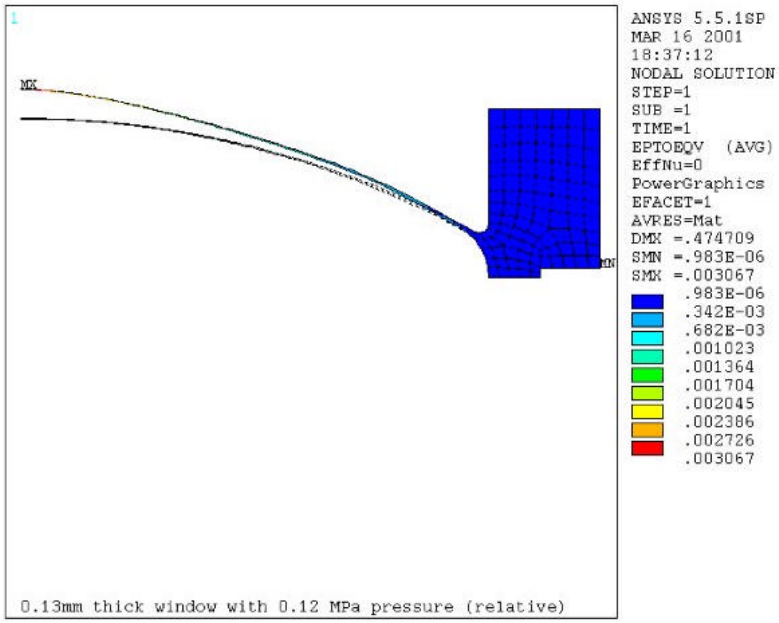
nu=0.3

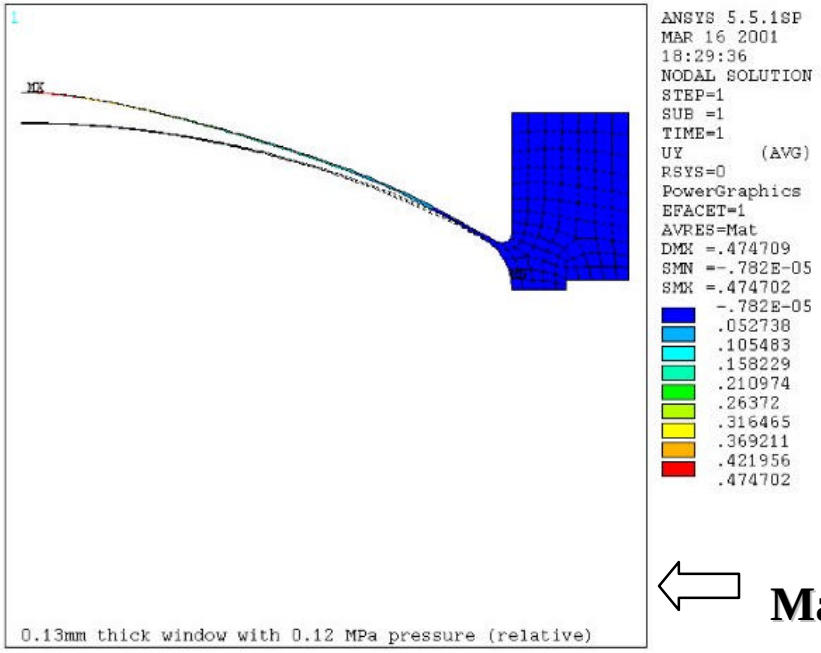
Numerical analysis of the windows

Case 1: 0.13mm thick window/ R15cm,

Load: 0.12MPa pressure

Max. equivalent strain is 3067 μE

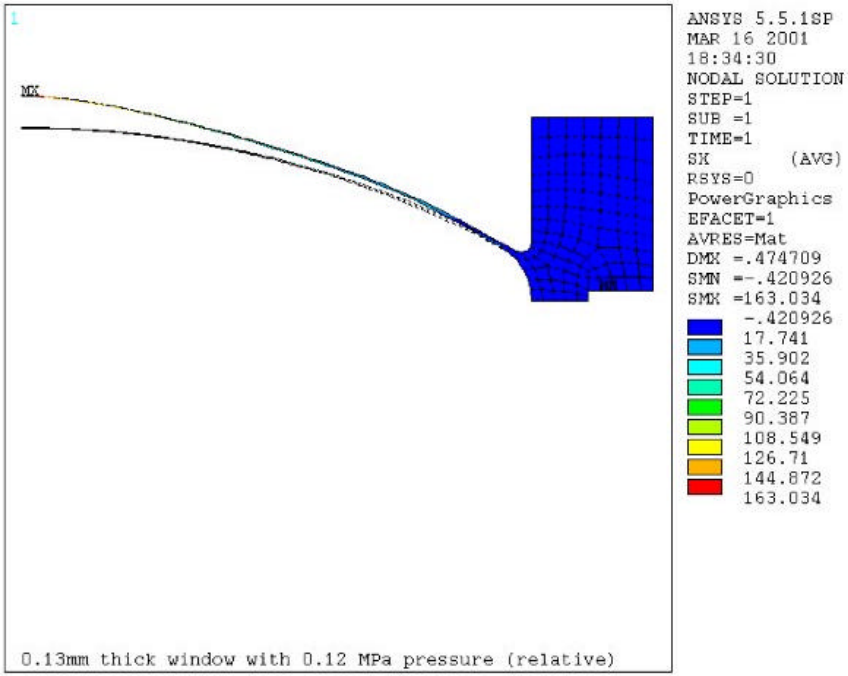


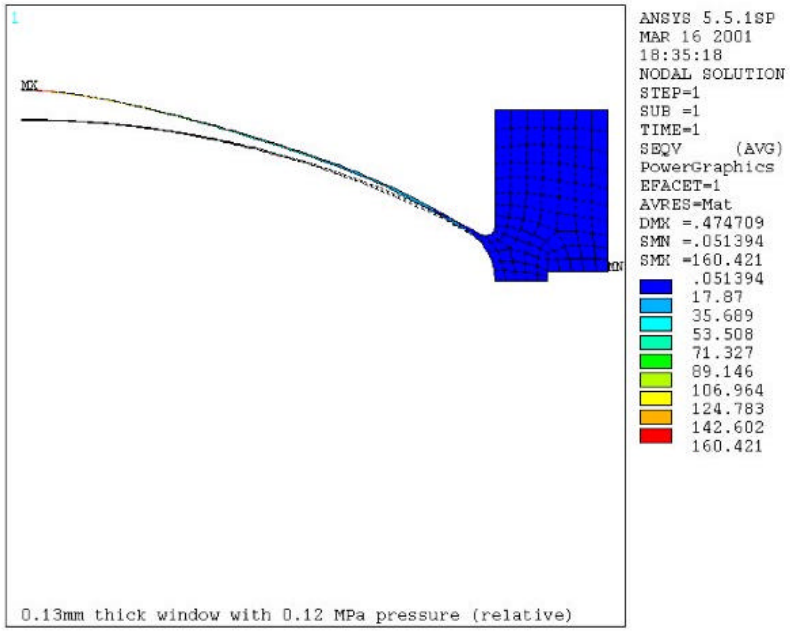


Max. deflection is 475 μm

Numerical analysis of the windows

Max. stress along X is 163 MPa

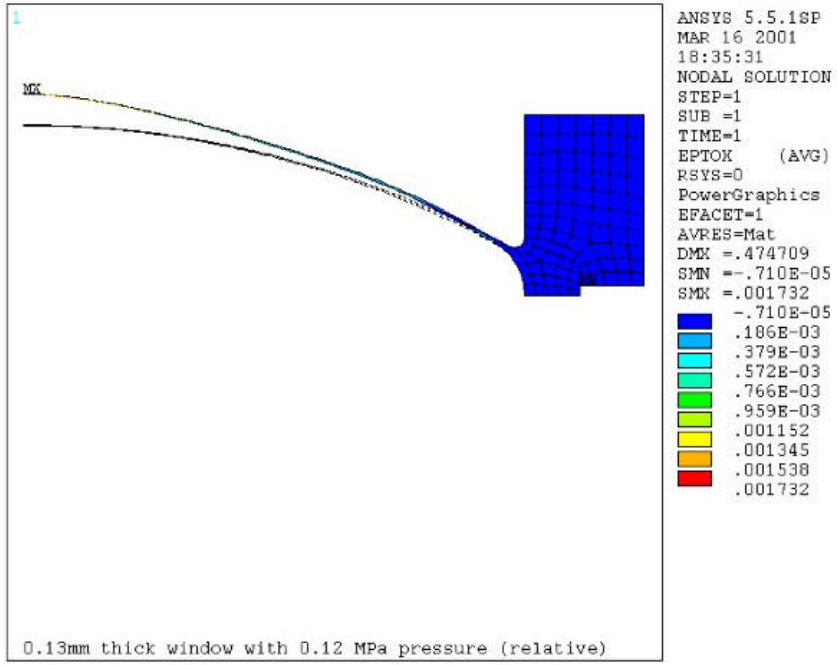


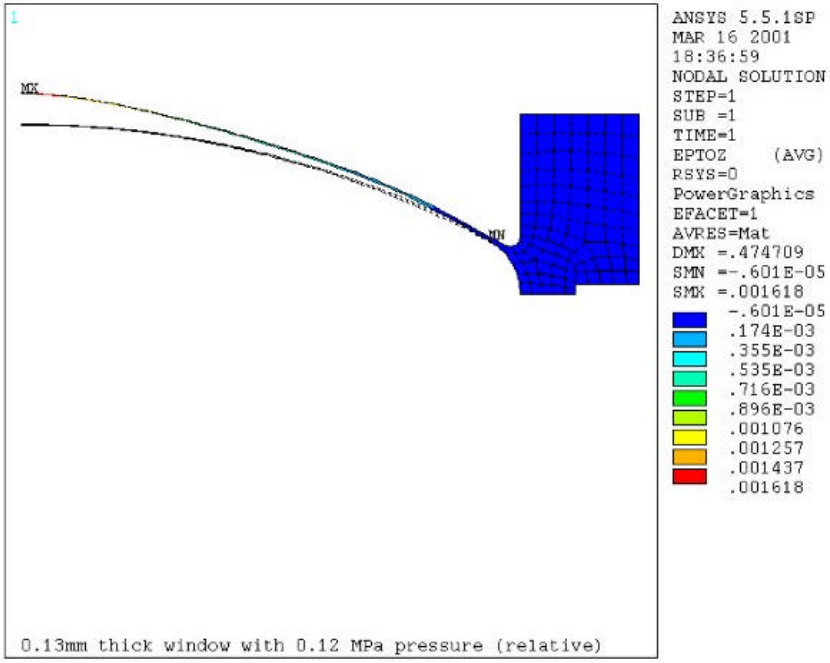


Max. stress (Von Mises) is 160 MPa

Numerical analysis of the windows

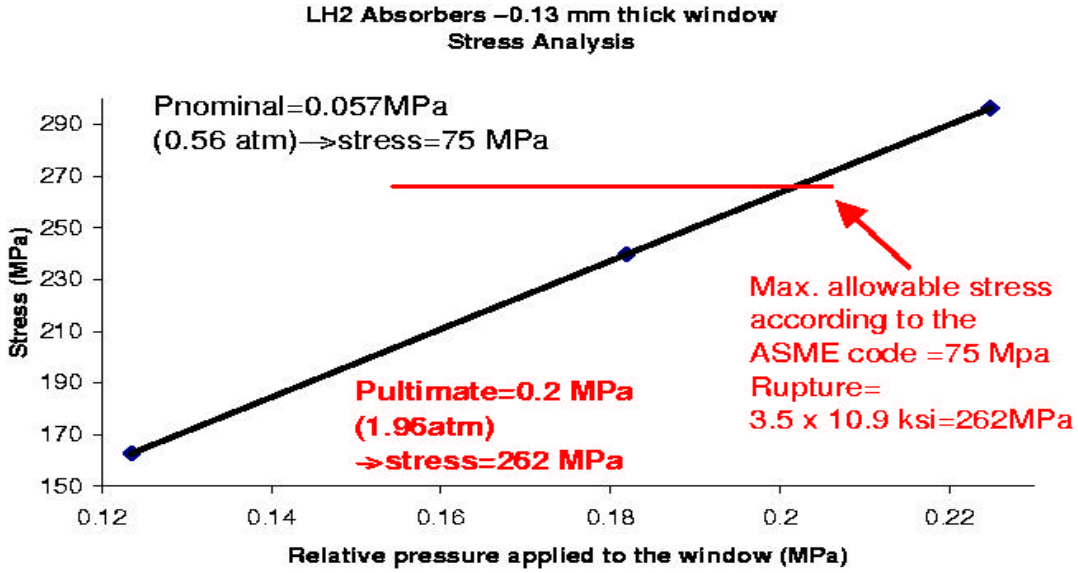
Max. strain along X is 1732 μE





Max. strain along Z is 1618 μE

Numerical analysis of the windows



Note: In accordance with the ASME code standards the maximum allowable stress for the 6061 T6 alloy is 75 Mpa
A safety factor of 3.5 is used to calculate the ultimate pressure, in accordance with the ASME code standards

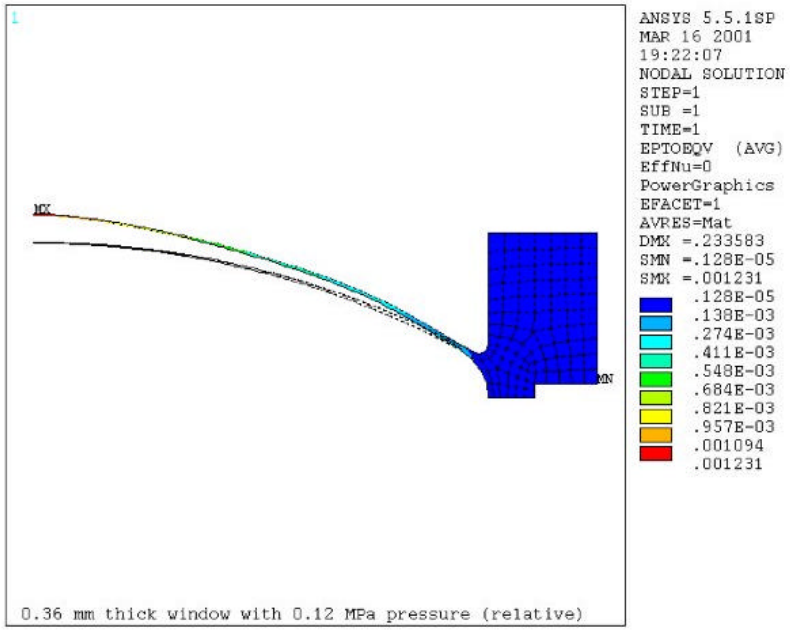
Christine Darve-02/27/01

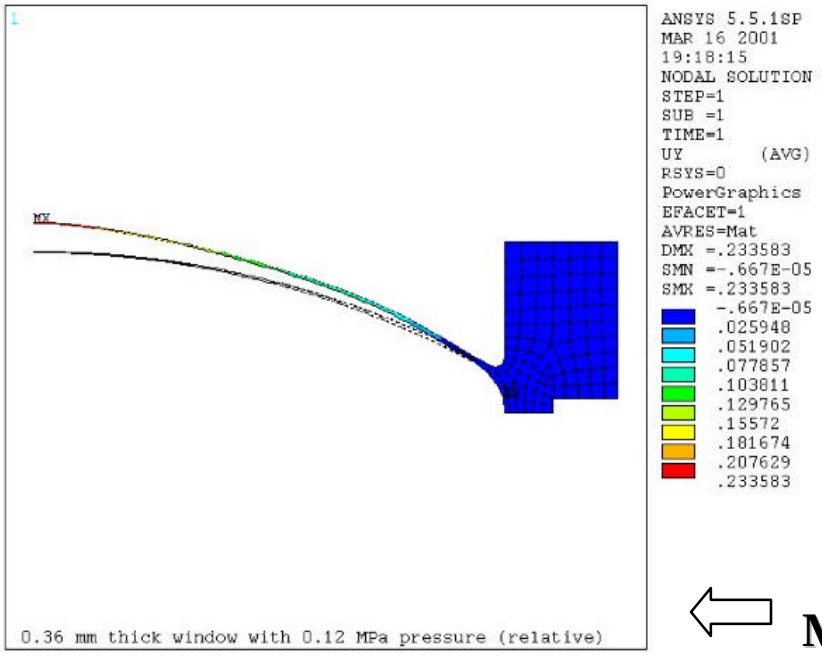
Numerical analysis of the windows

Case 2: 0.36mm thick window/ R18cm,

Load: 0.12MPa pressure

Max. equivalent strain is 1231 μE

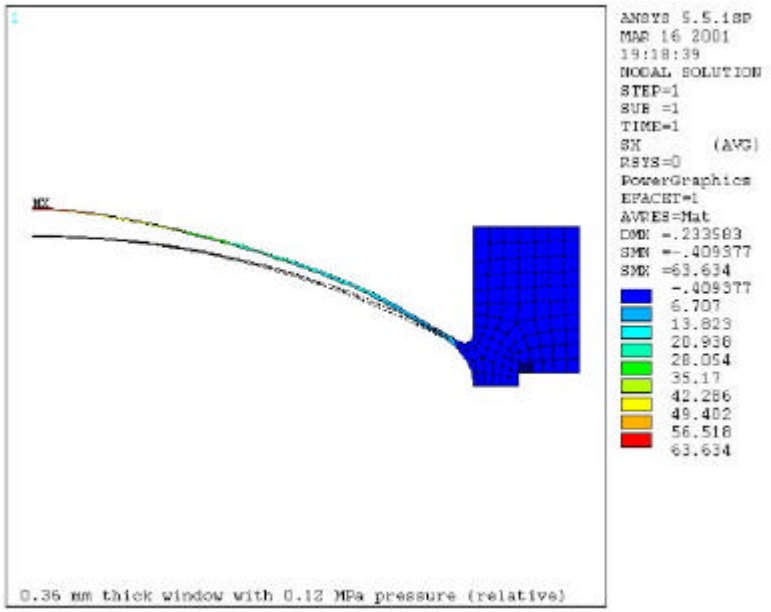


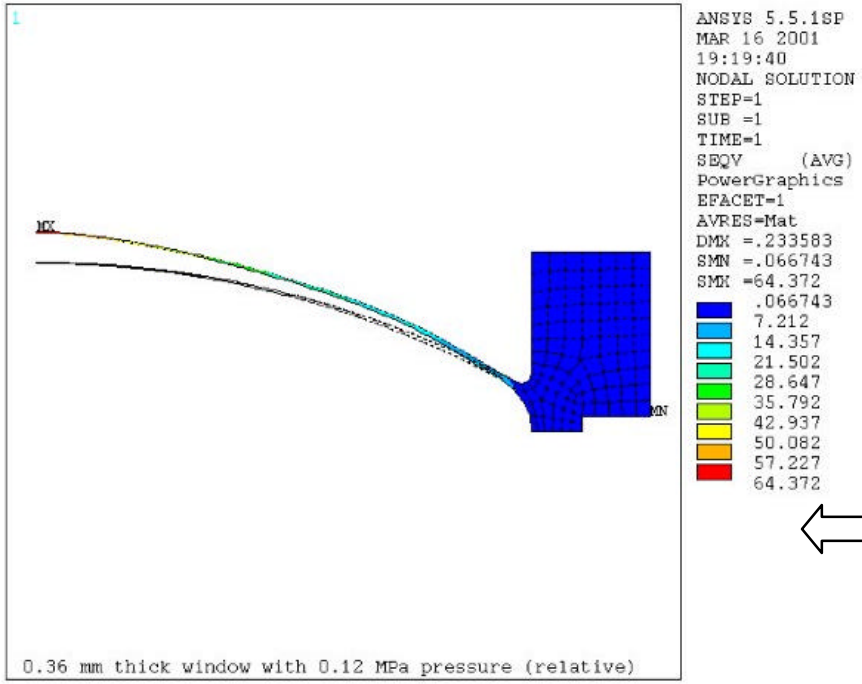


Max. deflection is 234 μm

Numerical analysis of the windows

Max. stress along X is 64 MPa

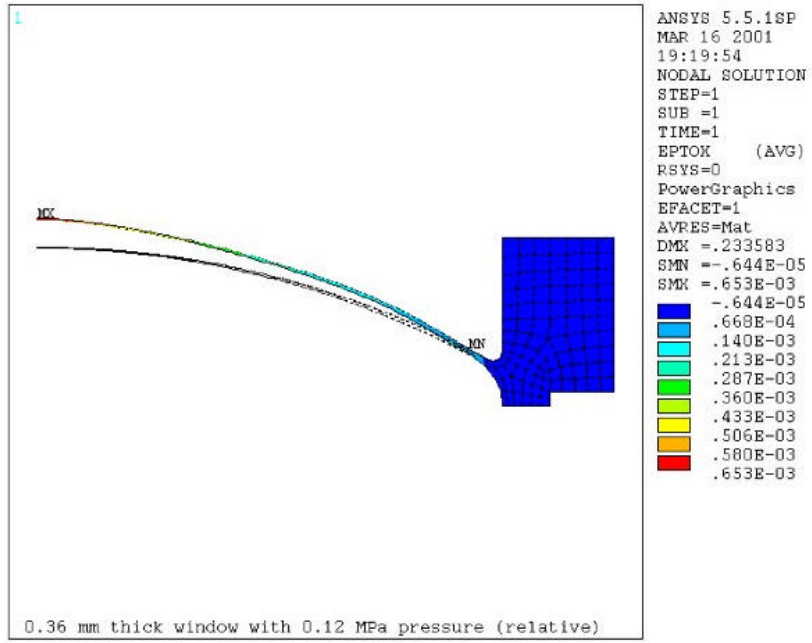


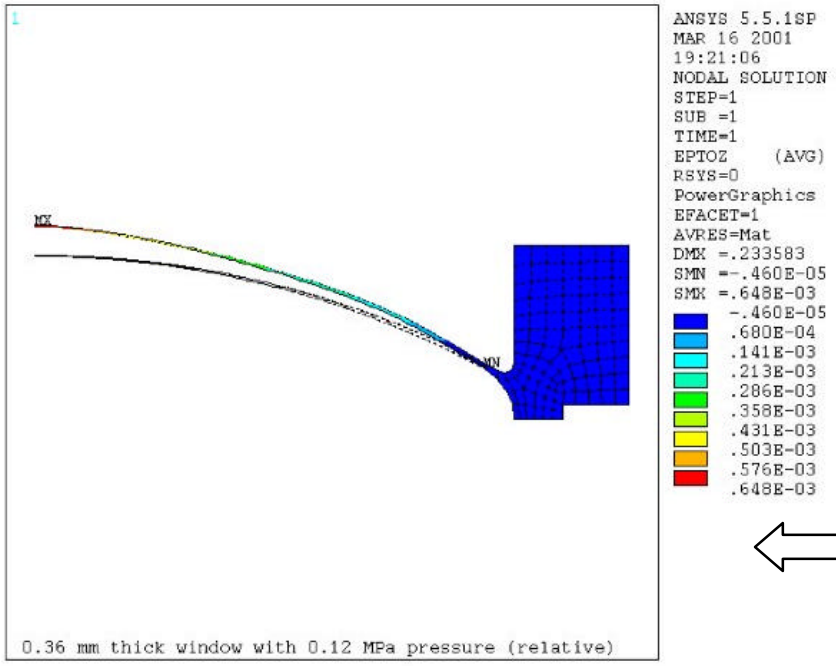


Max. stress (Von Mises) is 64 MPa

Numerical analysis of the windows

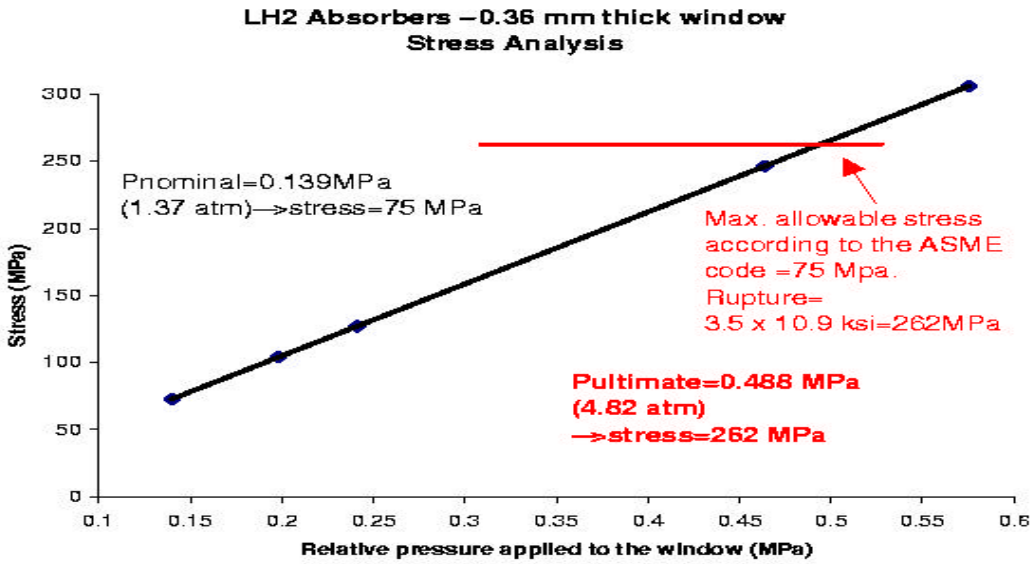
Max. strain along X is 653 μE





Max. strain along Z is 648 μE

Numerical analysis of the windows



Note: In accordance with the ASME code standards the maximum allowable stress for the 6061 T6 alloy is 75 Mpa
A safety factor of 3.5 is used to calculate the ultimate pressure, in accordance with the ASME code standards

Ch. Darve – 03/06/01

Set-up and instrumentation of the test pressure

Goal of the pressure test:

Validation of the numerical analysis for a 0.13 mm thick absorber window

Simulate the MUCOOL condition regarding pressure (Hydraulic test @RT)

What ? the critical part => Absorber window / Al 6061 T6

How ? = pressure applied to the window,

= measurement of the strain,

= measurement of the maximum available stress (=>Rupture)

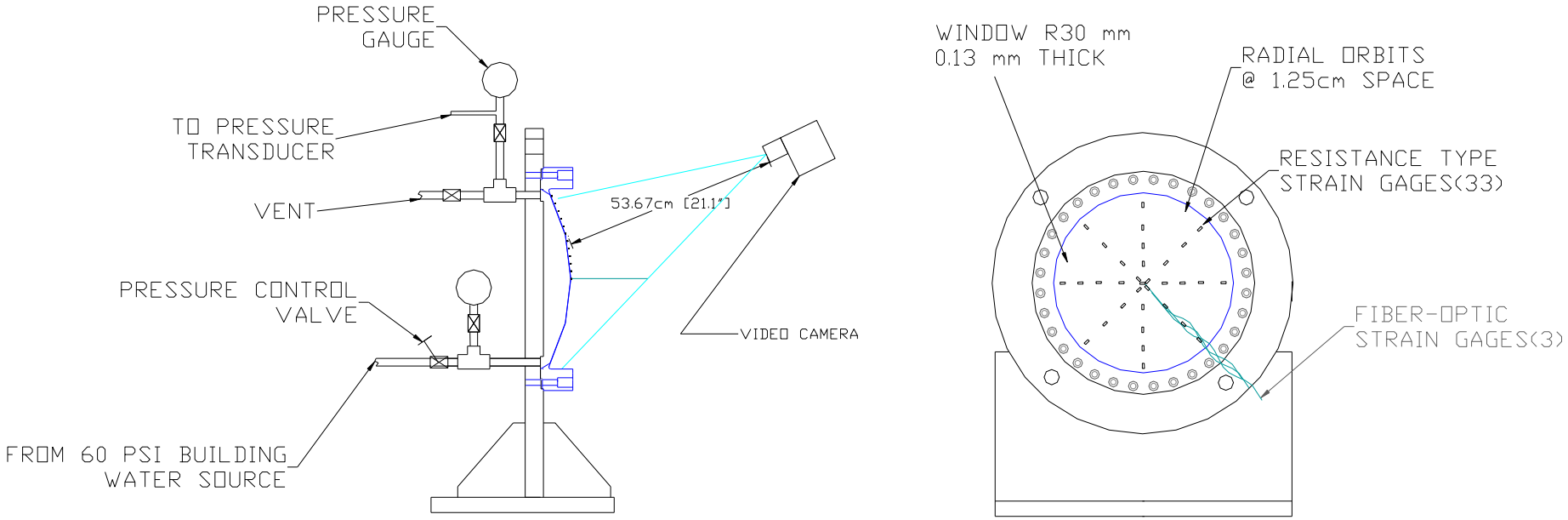
Procedure:

Strain gages

Pressure transducer

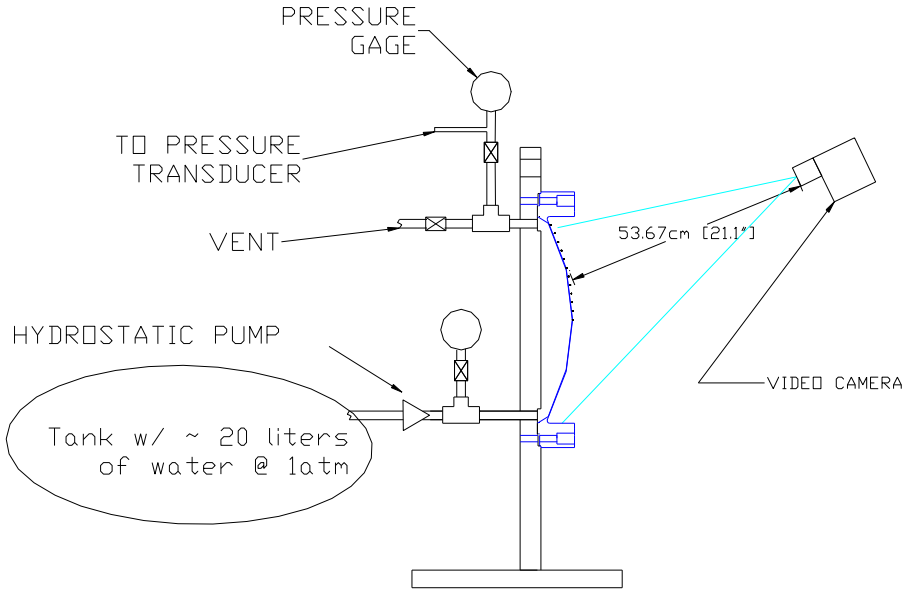
Regulation of the pressure

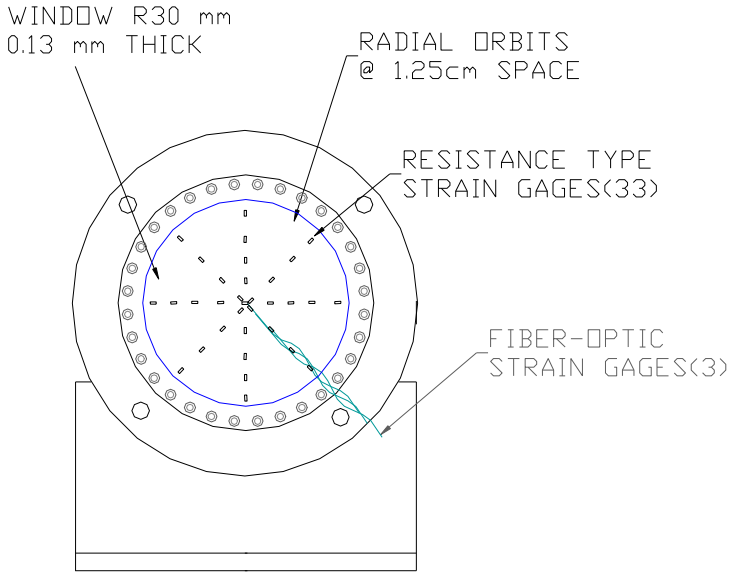
Set-up and instrumentation of the test pressure



WINDOW PRESSURE TEST SETUP

Set-up and instrumentation of the test pressure





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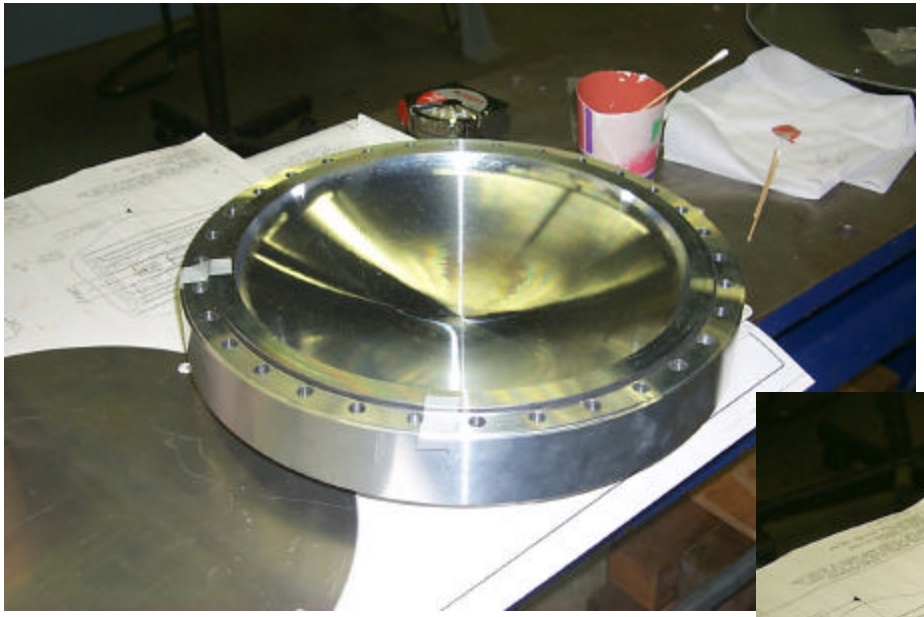

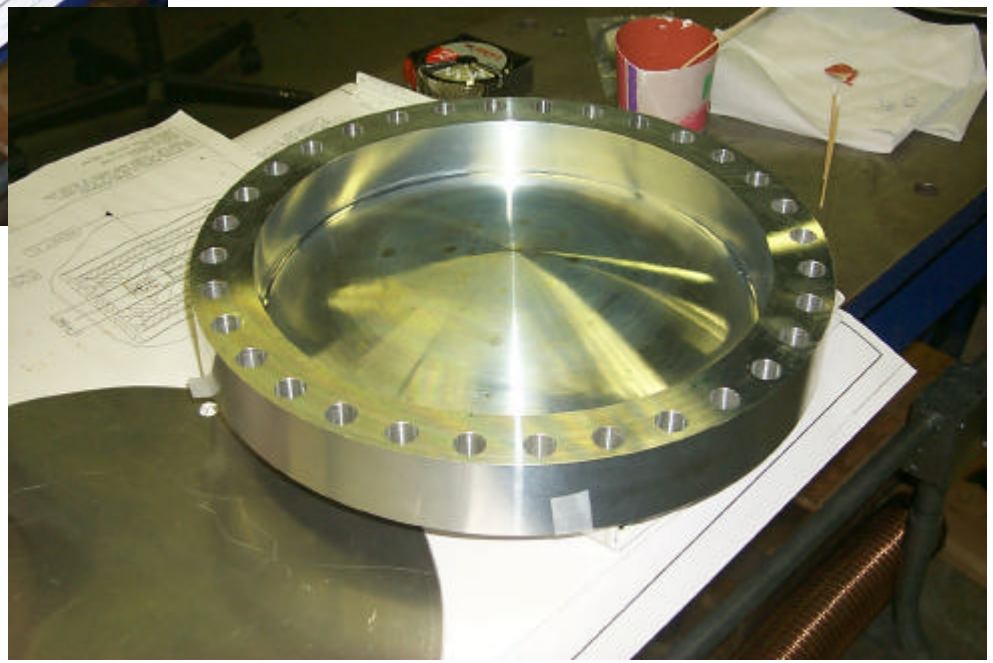

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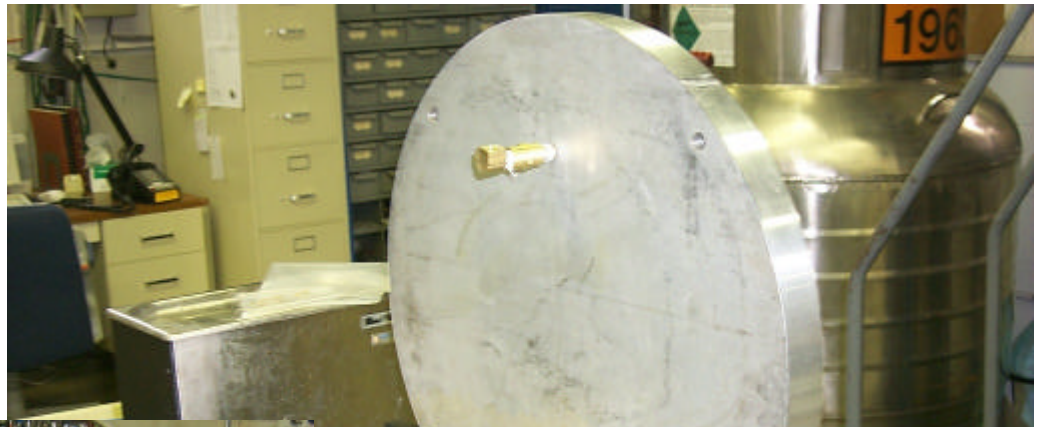

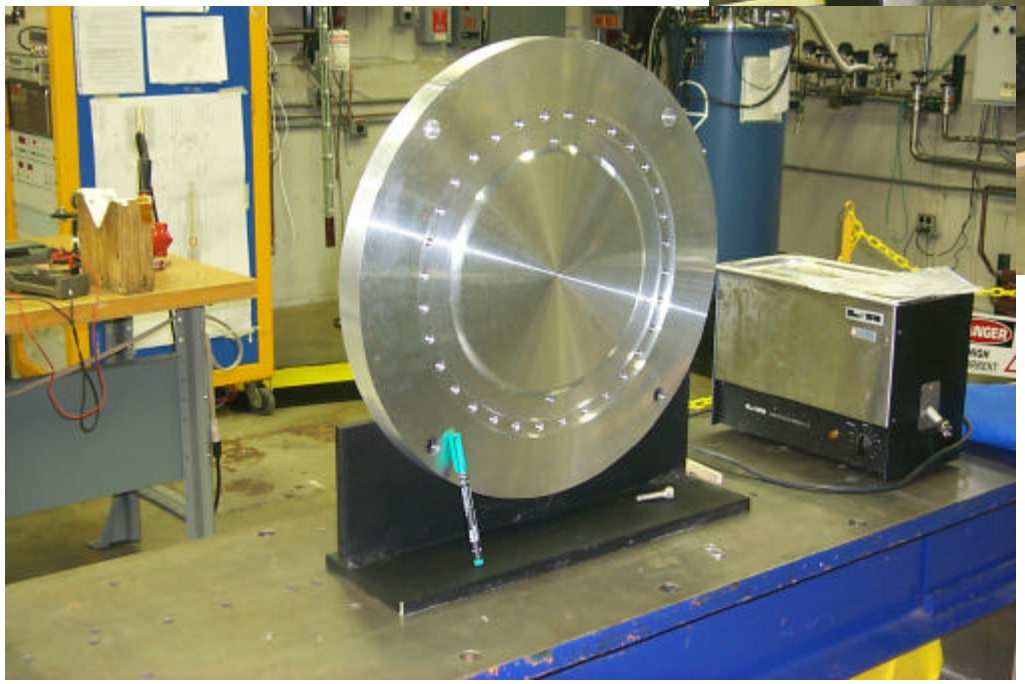

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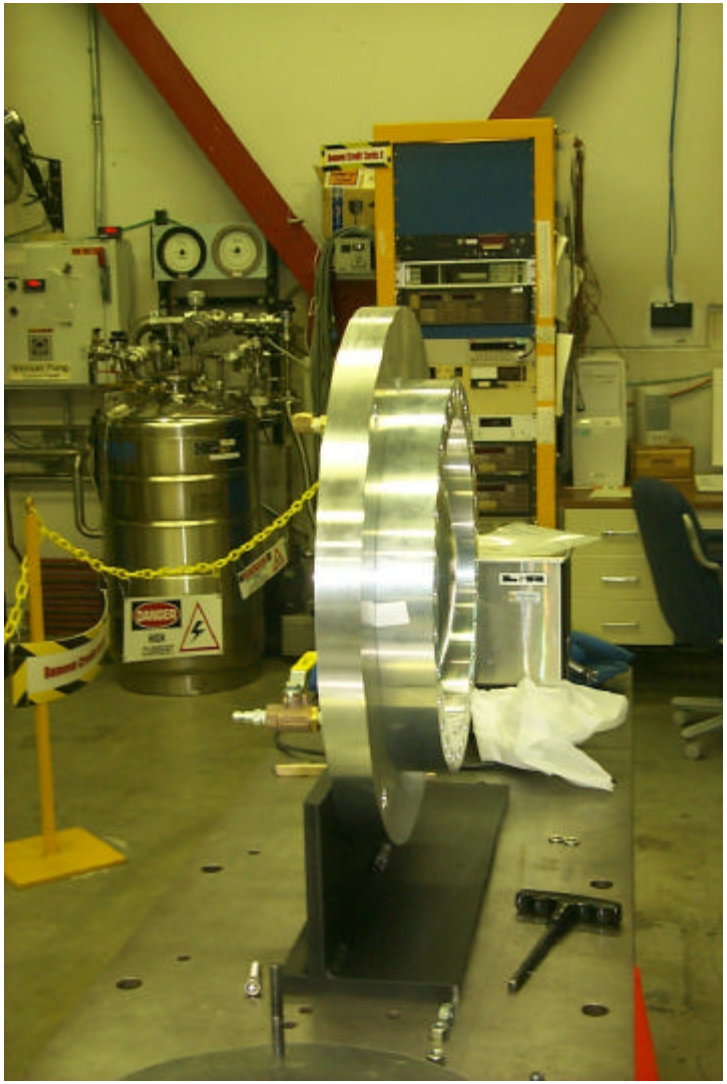

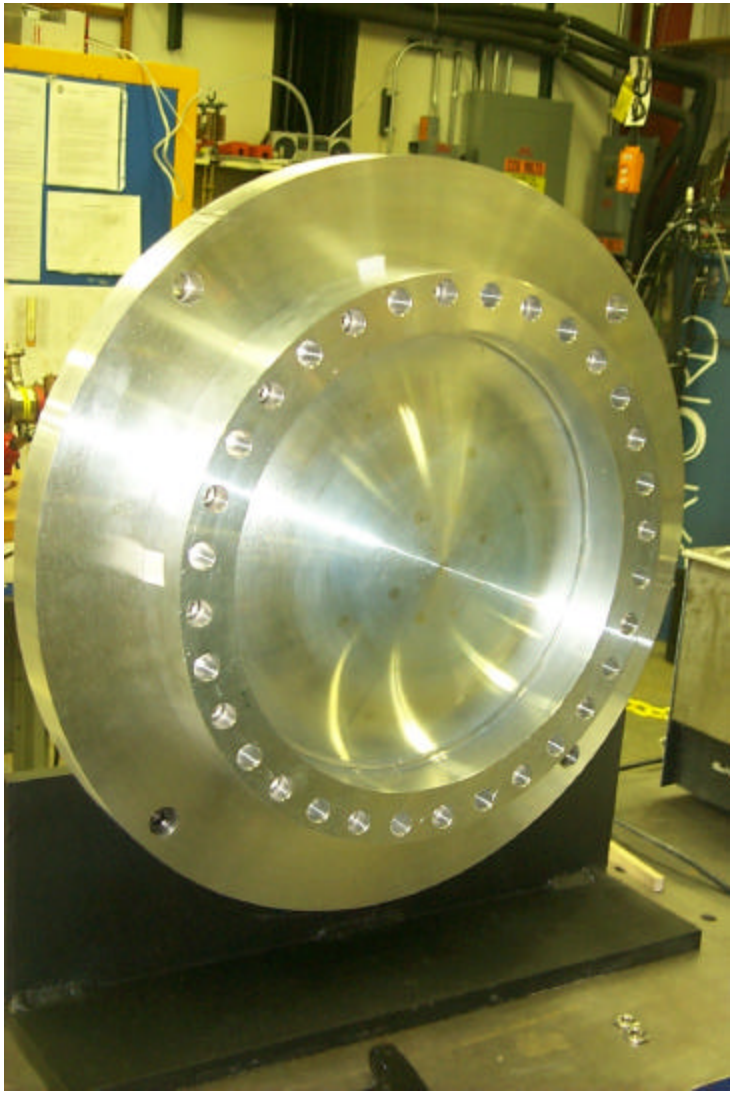

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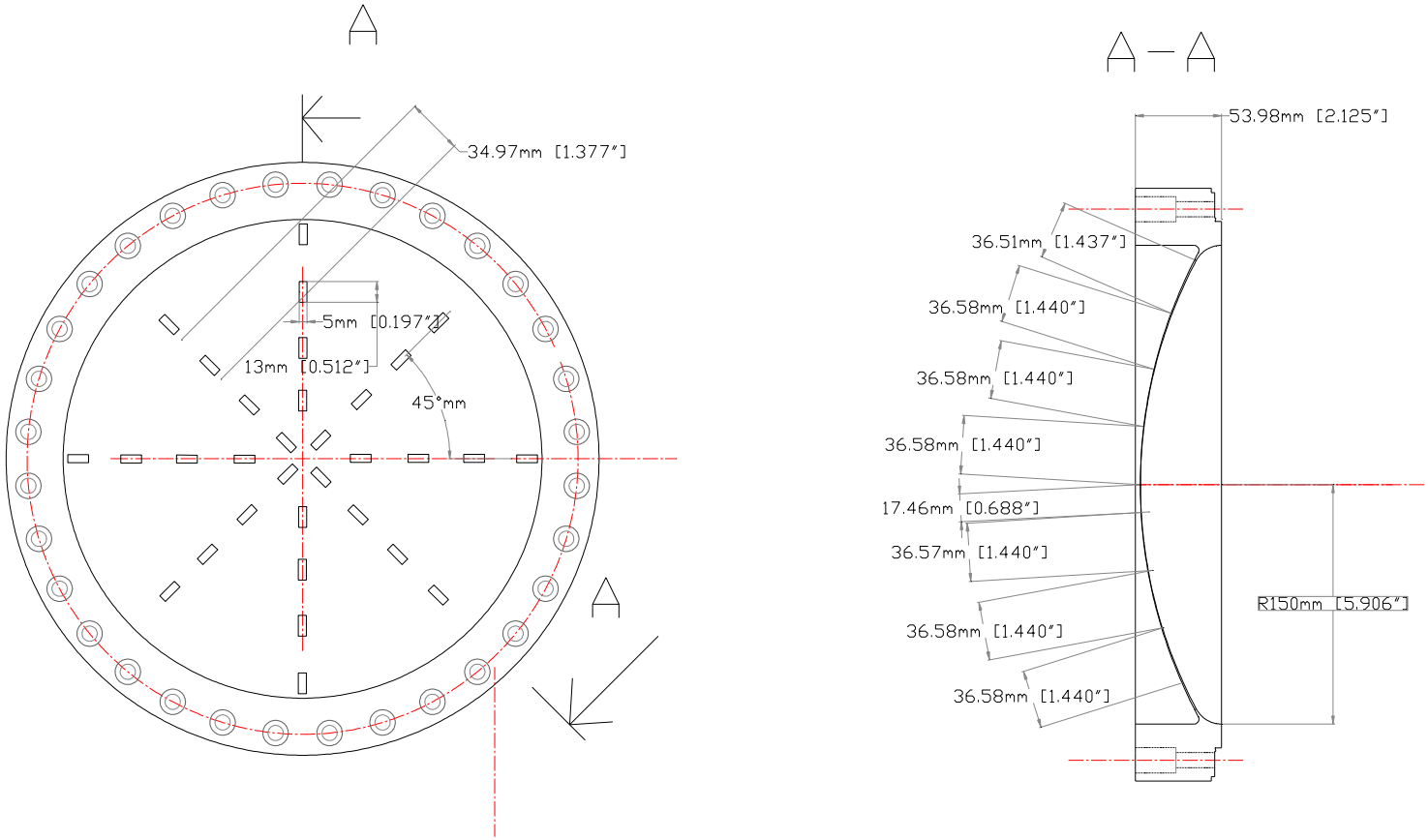


PRESSURE TEST ABSORBER WINDOW
STRAIN GAGES INSTALLATION

Set-up and instrumentation of the test pressure

Strain gages - Specification:

Construction: Fully encapsulated grid with exposed copper-coated tabs

Foil Alloy: Constantan

Carrier Matrix: Polyimide

Nominal gage thickness: 0.056mm

Strain limits: +/-3%

===> Estimation of the influence of the strain gages installation over the mechanical property of the window.

Max. strain to measure:

Al 6061 T6 (E= 7.104 @RT, δ=262 Mpa)

$$\epsilon = \frac{\delta}{E} \sim 3700\ \mu\epsilon$$

Set-up and instrumentation of the test pressure

Goal: Strain gages need to be assembled on the 0.13 mm thick Aluminum window in order to record the behavior of the absorber window while it is pressurized to break.

Materials:

- 33 strain gages: model EA-03-250BF-350, option L
- "usual" glue for assembly on Aluminum support
- "usual" 4 color copper wires
- 11 connectors

Location of gages: On the convex side of the window, along the four concentric circles built as in the attached drawing, plus one gage on the middle.

How:

- Clean surface with adapted solvant.
- Applied gages on the aluminum window with their standard bonding adhesive.
- Gages should be installed so that the lead side is oriented toward the window flange.
- Gage leads should be bended in order to avoid any contact with the alumimum surface.
- Four copper wires (4 meters long) should be soldered to the two leads and routed toward the window flange: white/black and red/green
- Tape should only be used to protect wires on the window flange - no tape on the thin part of the window.
- The extremity of the wires should be assembled to connectors (three gages per connector).

Set-up and instrumentation of the test pressure

Difficulties foresee:

.A pressure must be applied to the strain gages and transfer to the thin layer in order to cure the bonding adhesive and releave from air inbetween the gage and the window.
.Convex surface to assemble the gages.

Solution proposed:

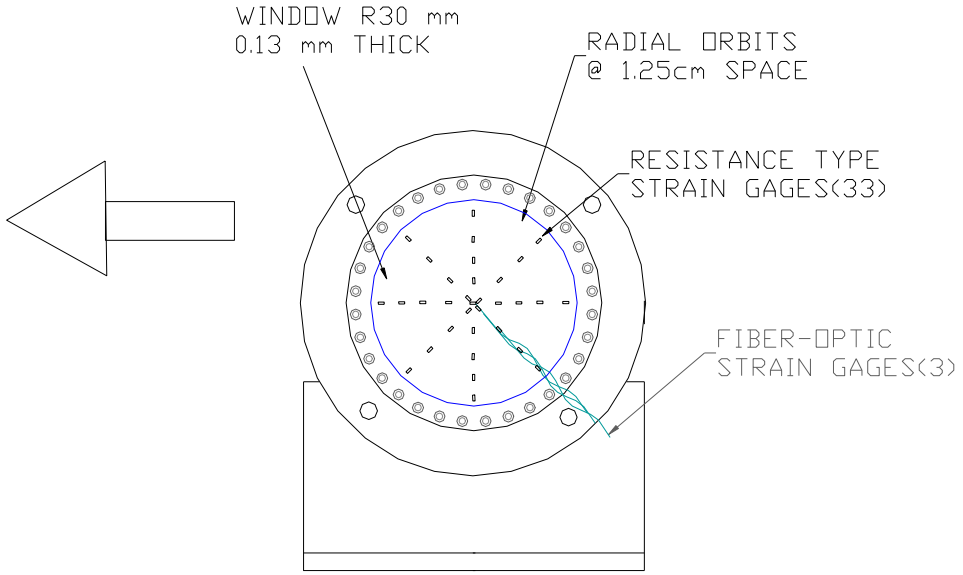
Fill partially the concave surface with a polymer that will stiffen the aluminum window and permit to assemble the strain gages. The polymer can be removed easily after the strain gages will be installed.
- RTV-41 (middle)
- DBT (curing agent)
==> durometry test = 50

Other possibility, if the aluminum plate is not estimate stiff enough: Fill the concave side by an epoxy resin (larger durometry).

With this principle the strain gages will be well assembled, avoiding the curve and the weakness of the window.

Set-up and instrumentation of the test pressure

Toward DAQ (switching system & DAQ board):
1 to 2 Pressure Transducers: (0-5V)
33 strain gages: (0-1 V)
3 fiber optic strain gages (signal conditioner : Analog output:+/- 10 V)



WINDOW PRESSURE TEST SETUP

Set-up and instrumentation of the test pressure